Integrated Monitoring for Harmful Algal Blooms

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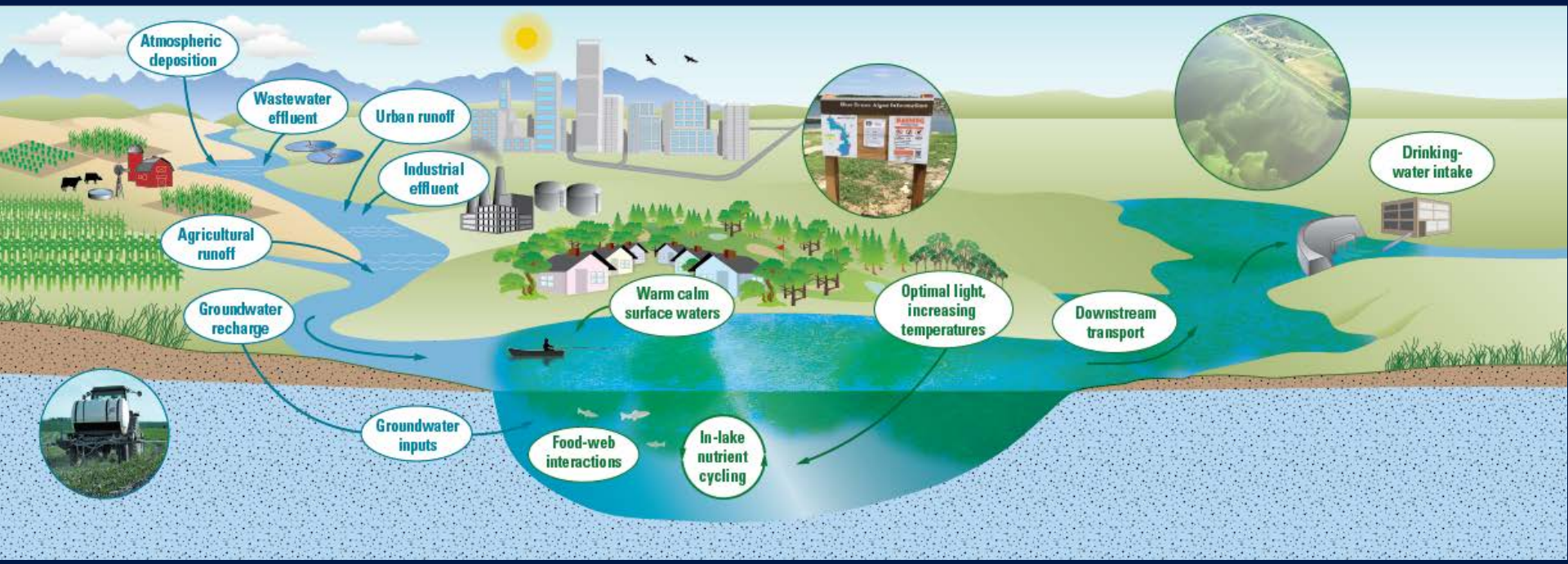
U.S. Geological Survey, Kansas Water Science Center

Kansas Department of Health and Environment Harmful Algal Bloom Workshop

January 18, 2018

Factors Contributing to Blooms:

Many environmental factors influence the occurrence of algal blooms.
In general, an algal bloom indicates an ecosystem imbalance.



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After Graham and others, 2016, USGS OFR 2016-1174
http://dx.doi.org/10.3133/ofr20161174

Integrated Monitoring is Essential to Understand, Quantify, and Mitigate Harmful Algal Blooms

- Individual systems are unique.
- Spatial and temporal variability present challenges to data collection, analysis, and interpretation.
- A range of sensor-based applications have been developed to quantify harmful algal bloom occurrence and severity.
- A variety of tools for early warning and prediction are being developed and used.

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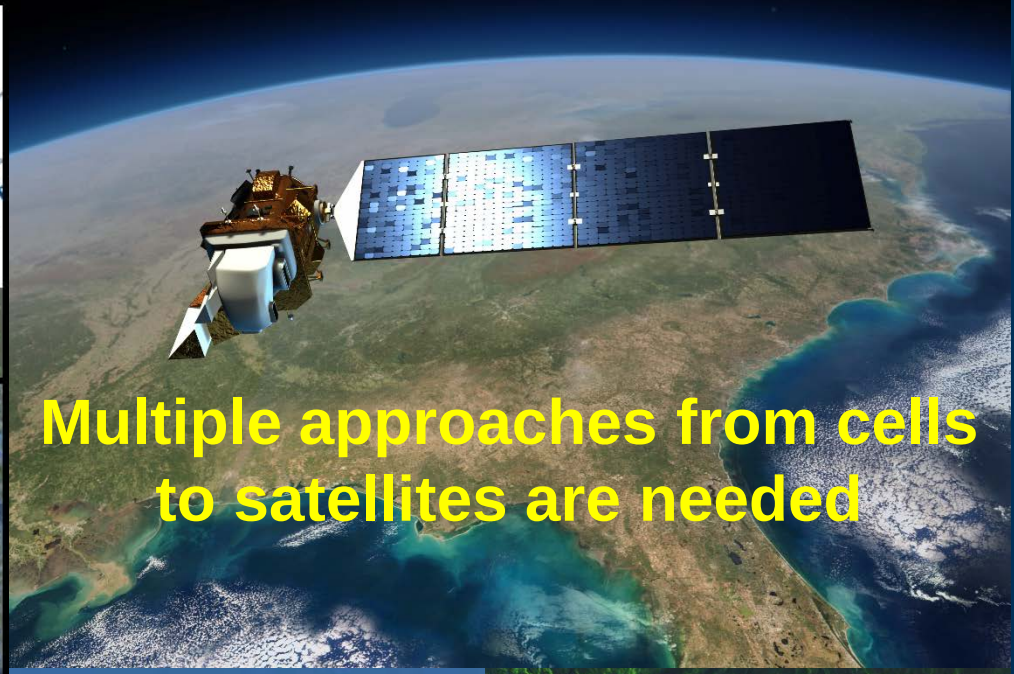
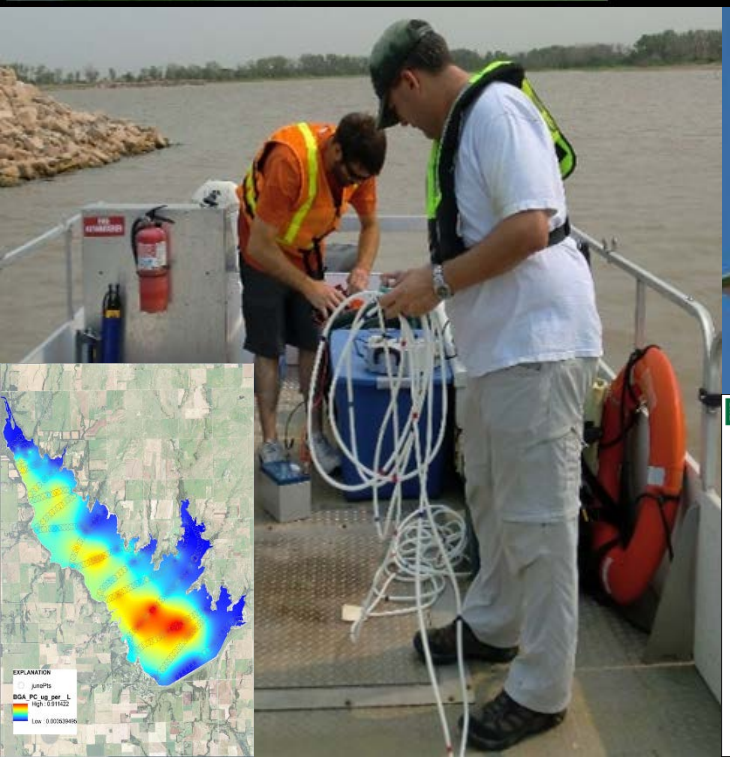
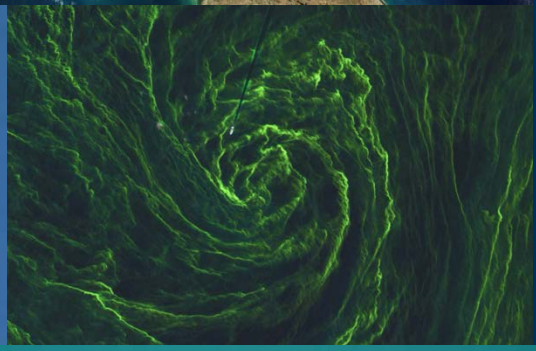
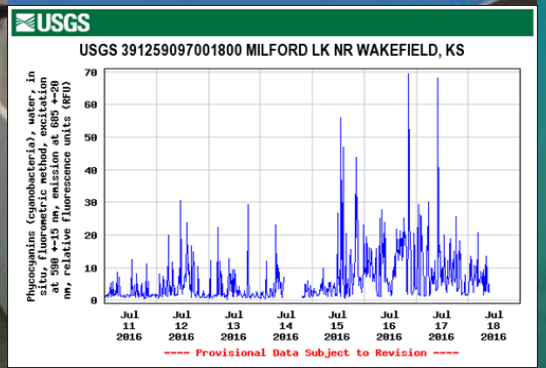
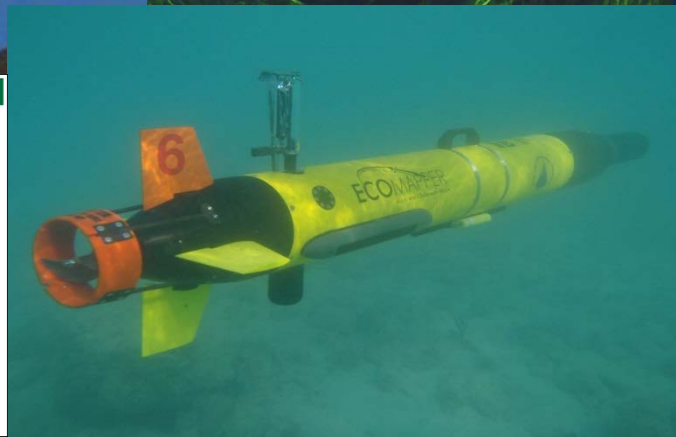


Multiple approaches from cells to satellites are needed

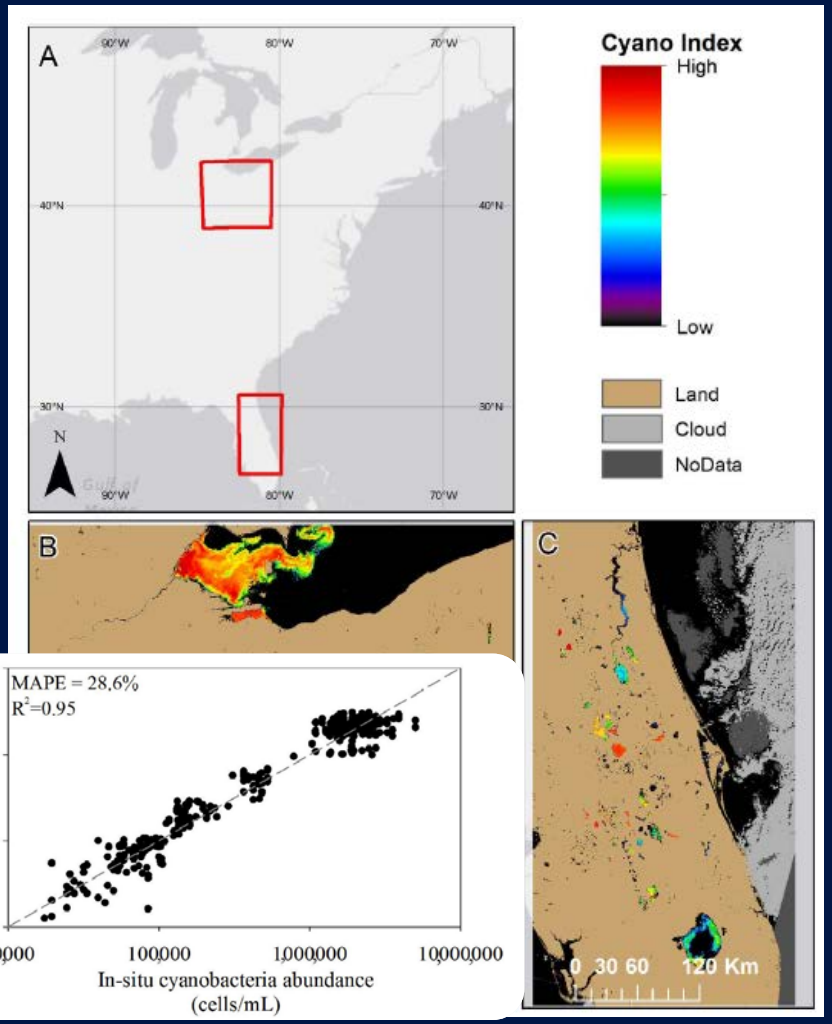


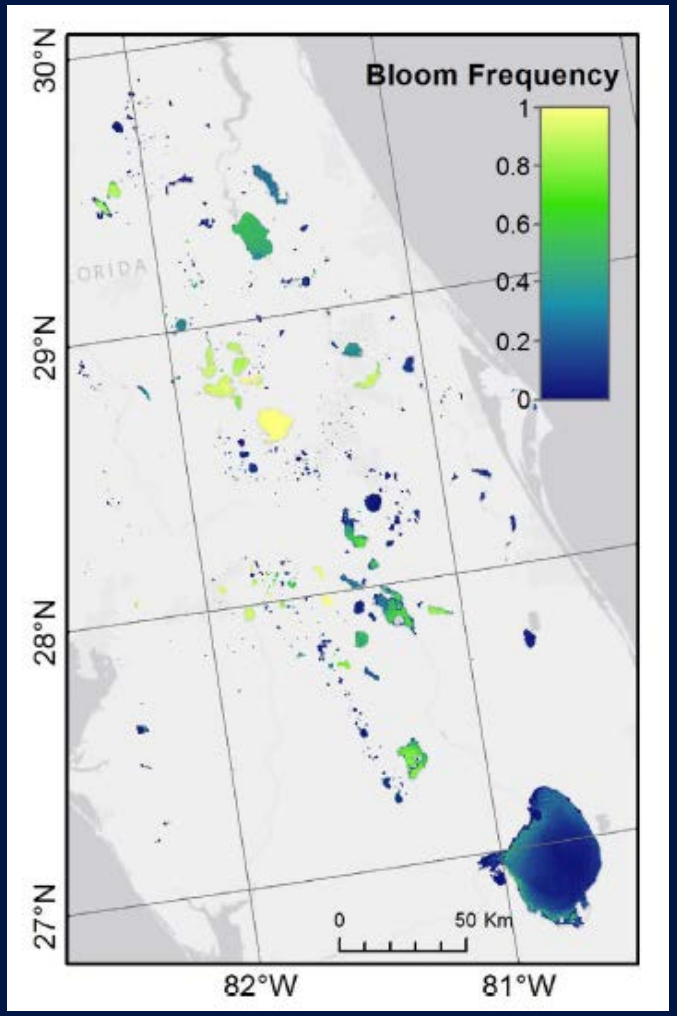






Satellite Imagery May Capture Spatial and Temporal Variability Across a Regional Scale





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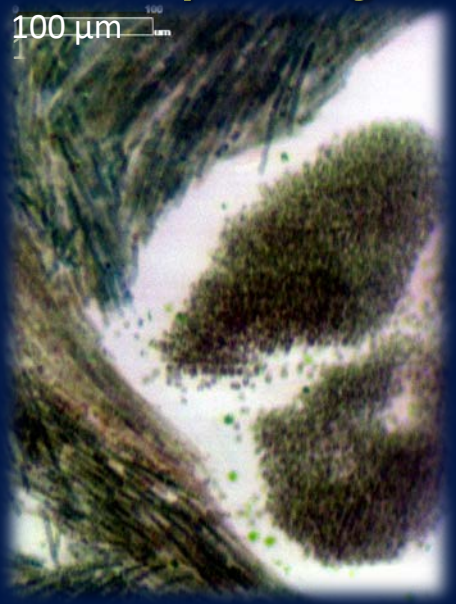
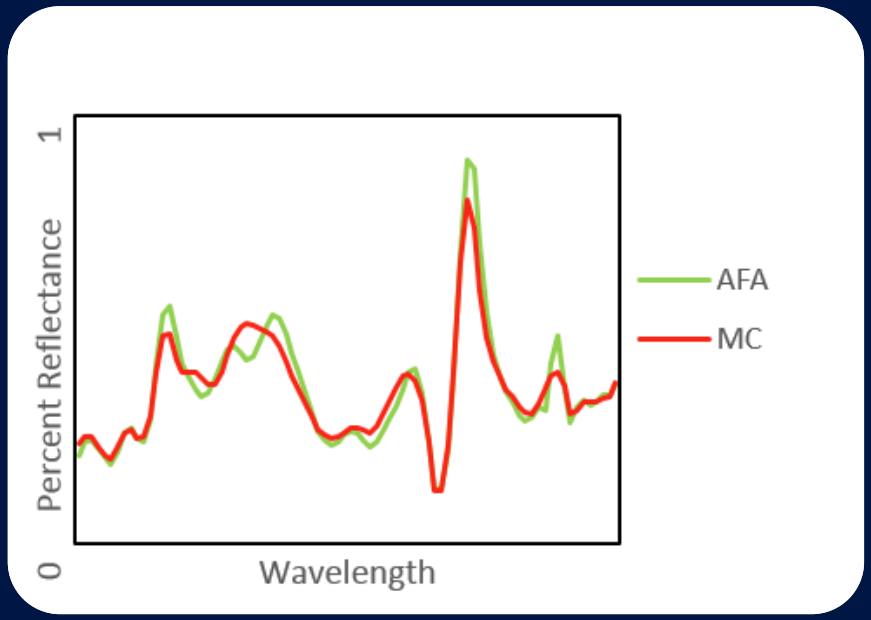
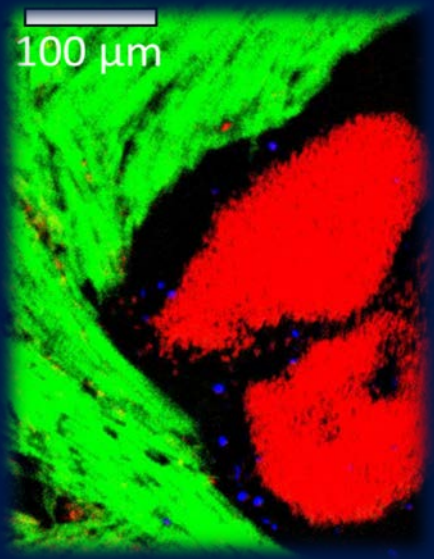
CYAN

After Clark and others, 2017
http://dx.doi.org/10.1016/j.ecolind.2017.04.046

Hyperspectral Microscopy Can Potentially Be Used to Identify Unique Signatures of Harmful Algal Bloom Forming Taxa







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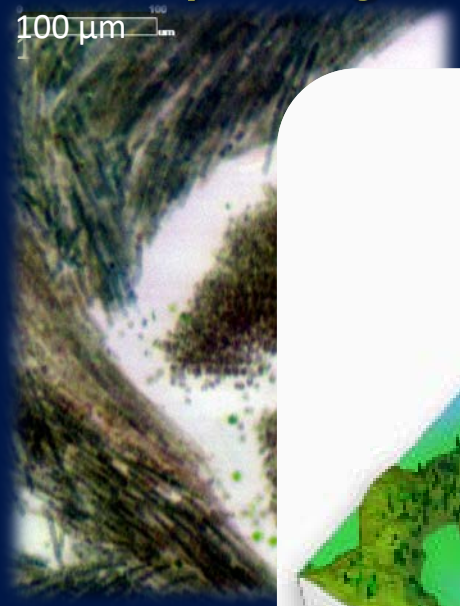
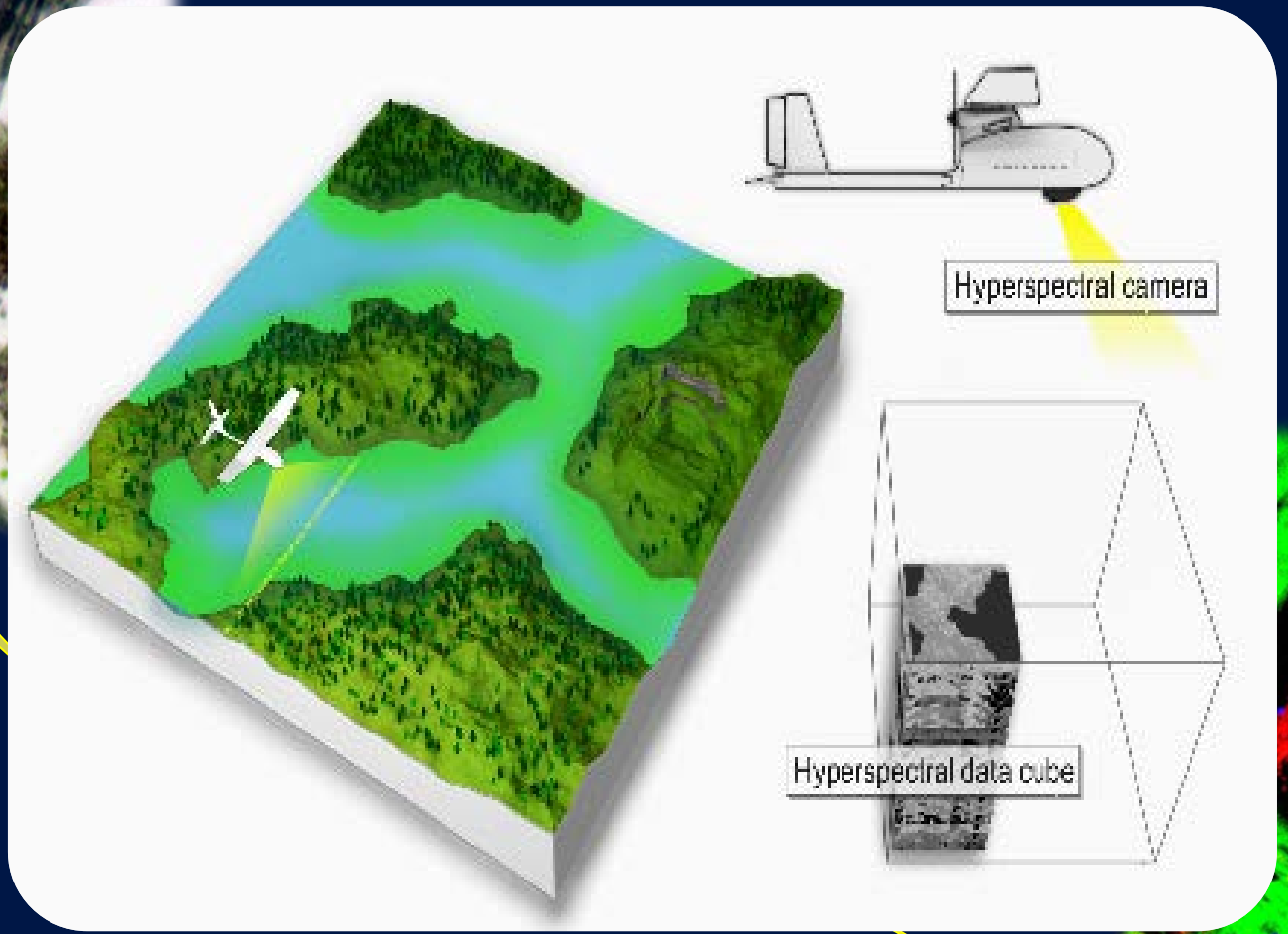
PML PHYSICAL MEASUREMENT LABORATORY

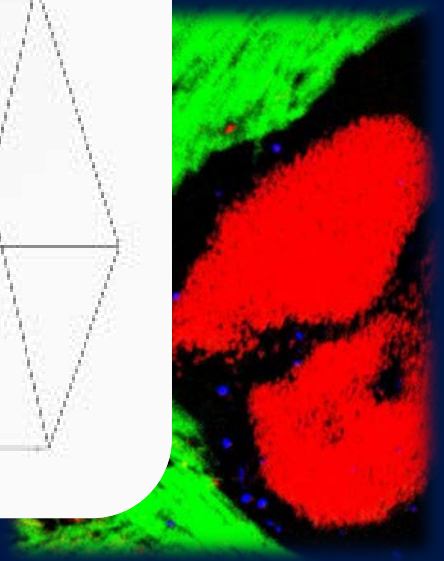
NIST National Institute of Standards and Technology U.S. Department of Commerce

Courtesy of T. Slonecker and N. Simon, USGS

Hyperspectral Microscopy Can Potentially Be Used to Identify Unique Signatures of Harmful Algal Bloom Forming Taxa







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PML PHYSICAL MEASUREMENT LABORATORY

NIST National Institute of Standards and Technology U.S. Department of Commerce

Courtesy of T. Slonecker and N. Simon, USGS

Aerial- and Ground-Based Cameras Show Potential as Early Warning Indicators

Courtesy of E. Emory

Courtesy of C. Smith

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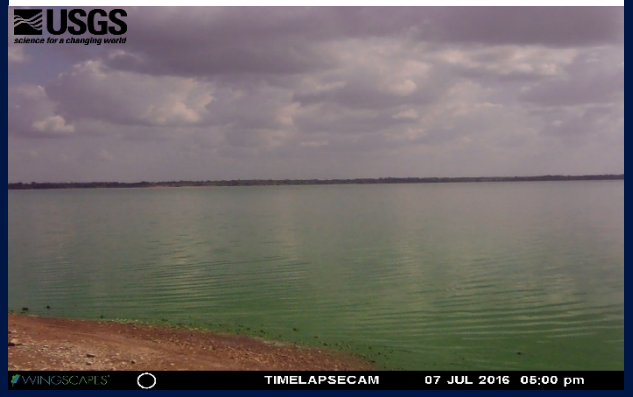
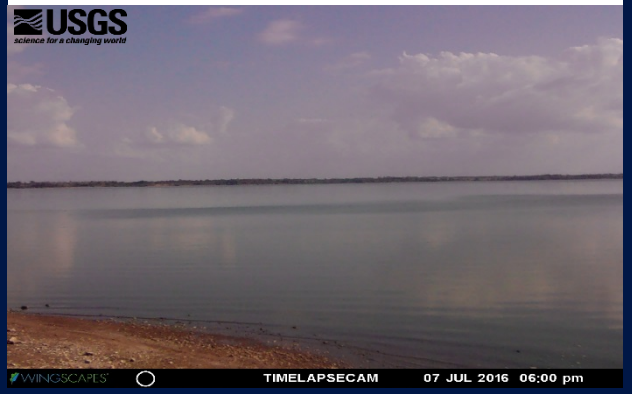
Time-Lapse Cameras Capture Temporal Variability at Sites of Interest

July 7, 2016 at 5:00 pm



July 7, 2016 at 6:00 pm



July 20, 2016 at 3:54 pm

July 20, 2016 4:09 pm

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Underwater Cameras Capture Periphyton Growth at Locations that Are Otherwise Difficult to Sample

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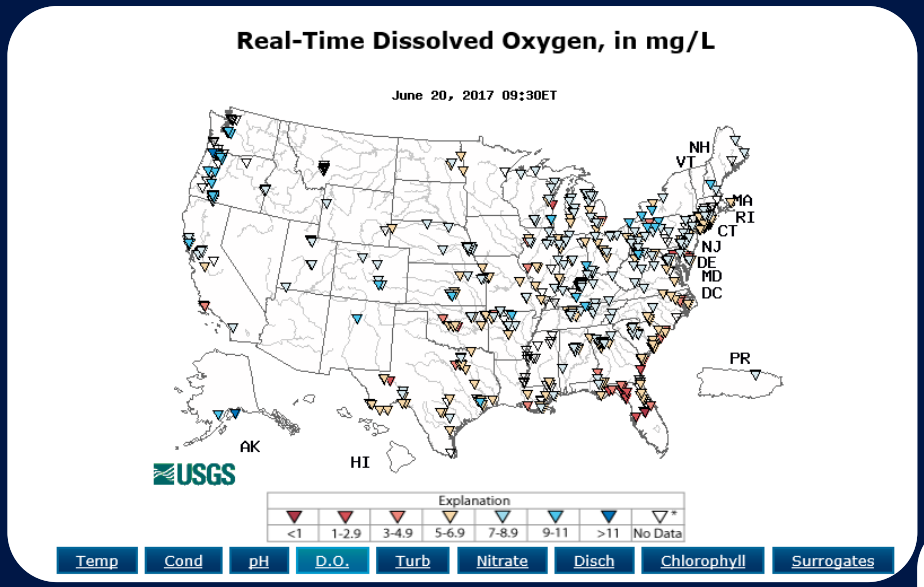
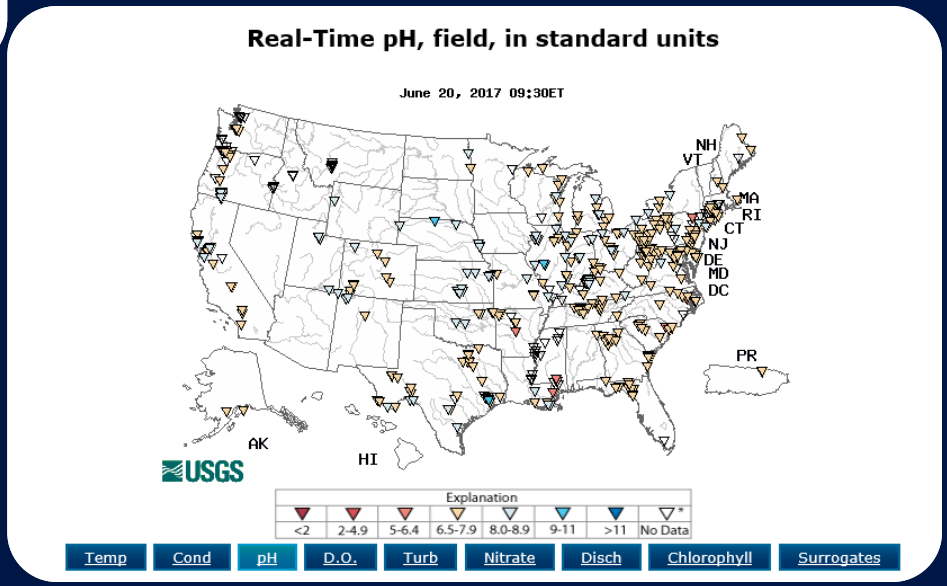
Courtesy of R. Naranjo
"Whiskey is for drinking, peri is for phyton"

There are Several Hundred Sites Throughout the Nation with Dissolved Oxygen and pH Sensors





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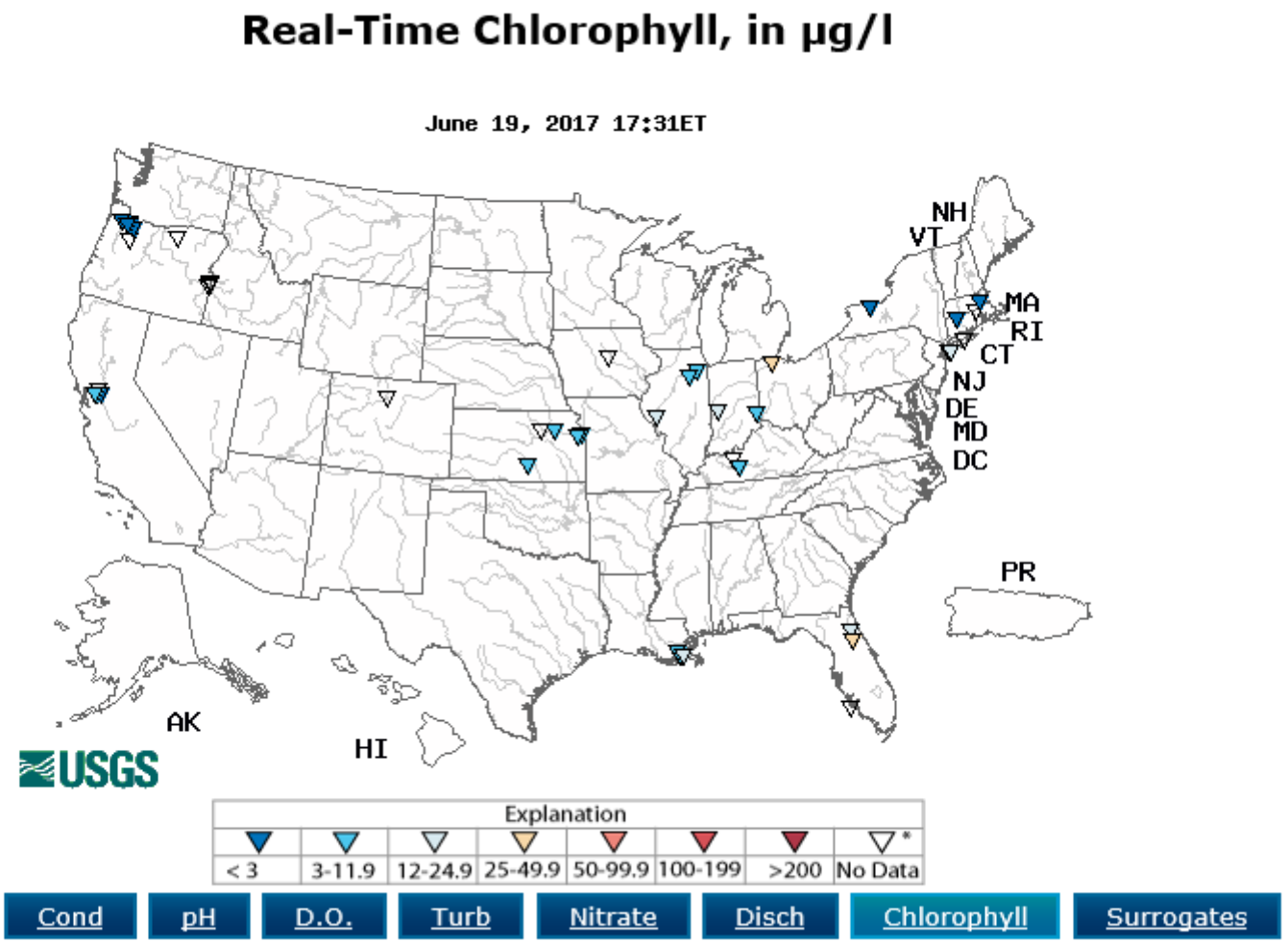
https://waterwatch.usgs.gov/wqwatch/

There are About 60 Sites Throughout the Nation with Chlorophyll Fluorescence Sensors



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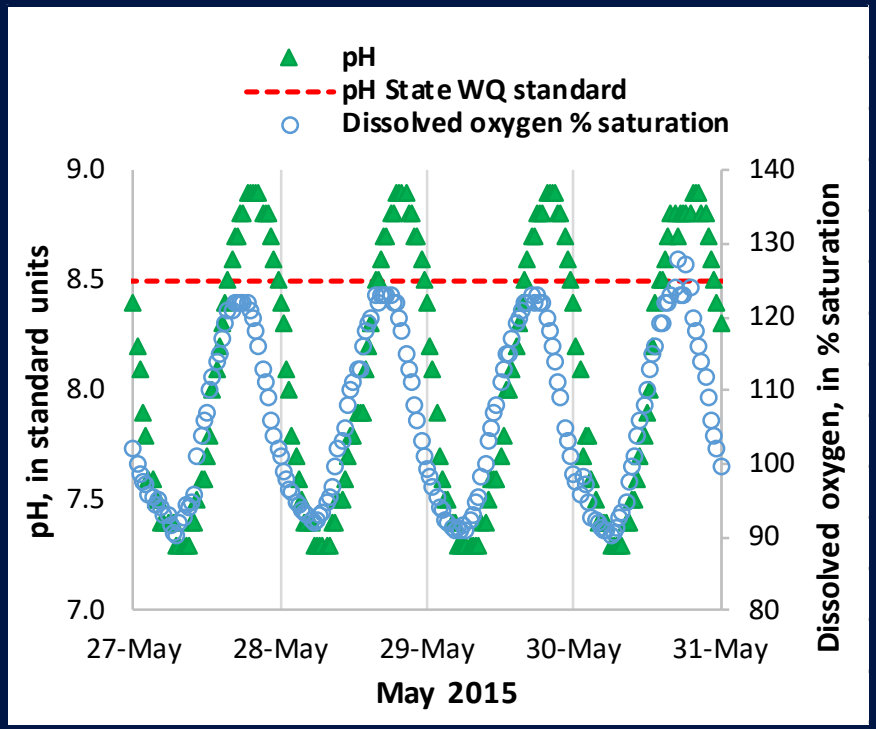
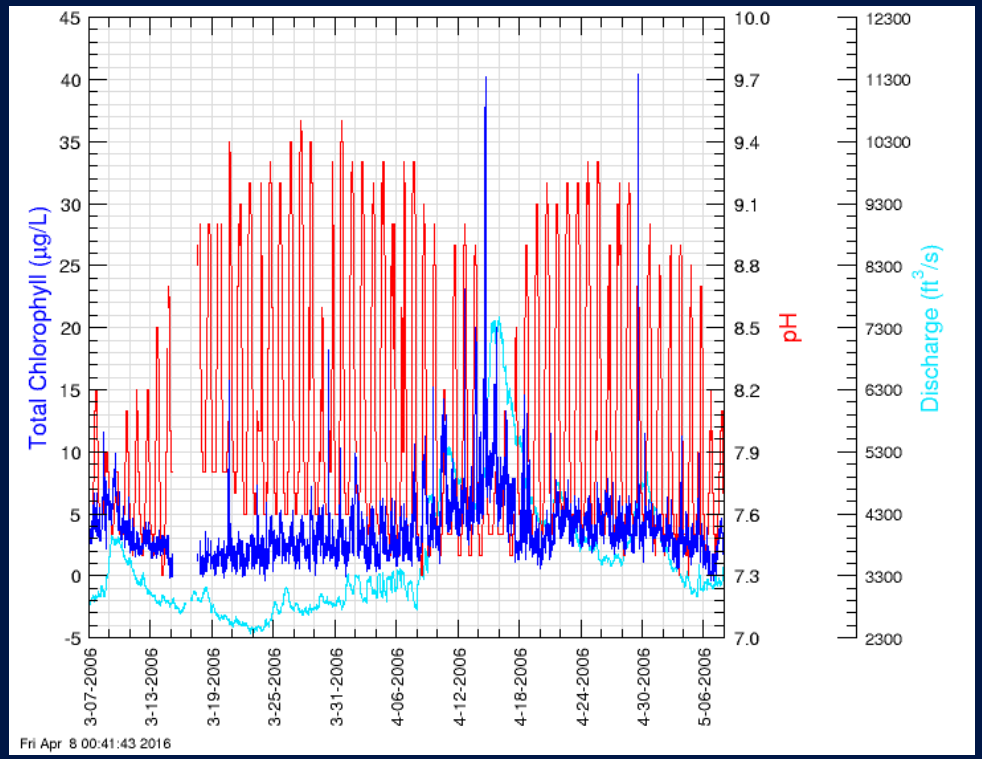
https://waterwatch.usgs.gov/wqwatch/

Diurnal Patterns in pH, Dissolved Oxygen, and Algal Fluorescence are Indicative of Potentially Harmful Algal Blooms





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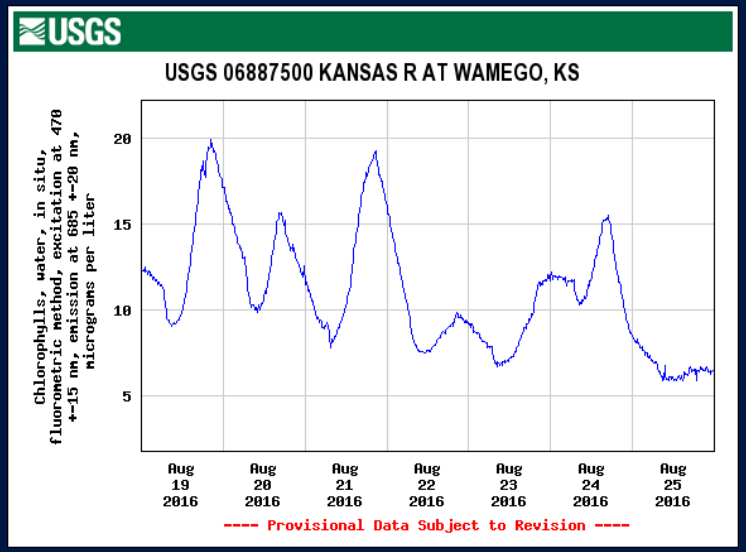
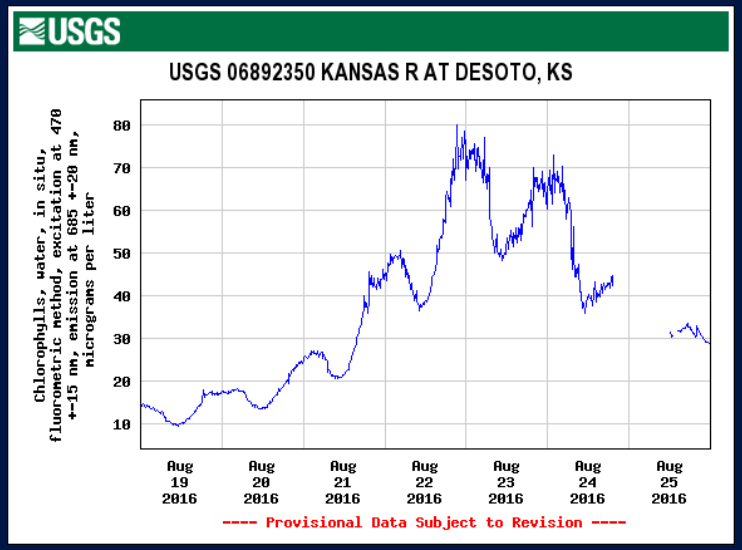
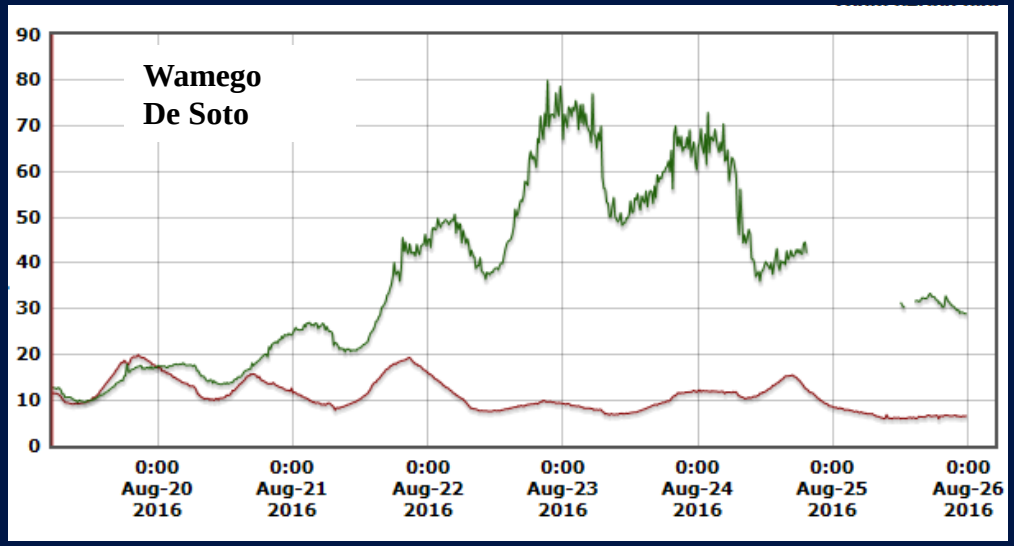
http://or.water.usgs.gov/clackamas/monitors/

Courtesy of C. Carpenter

Algal Fluorescence (as Well as DO and pH) May Be Indicative of Among-Site Differences in Algal Activity







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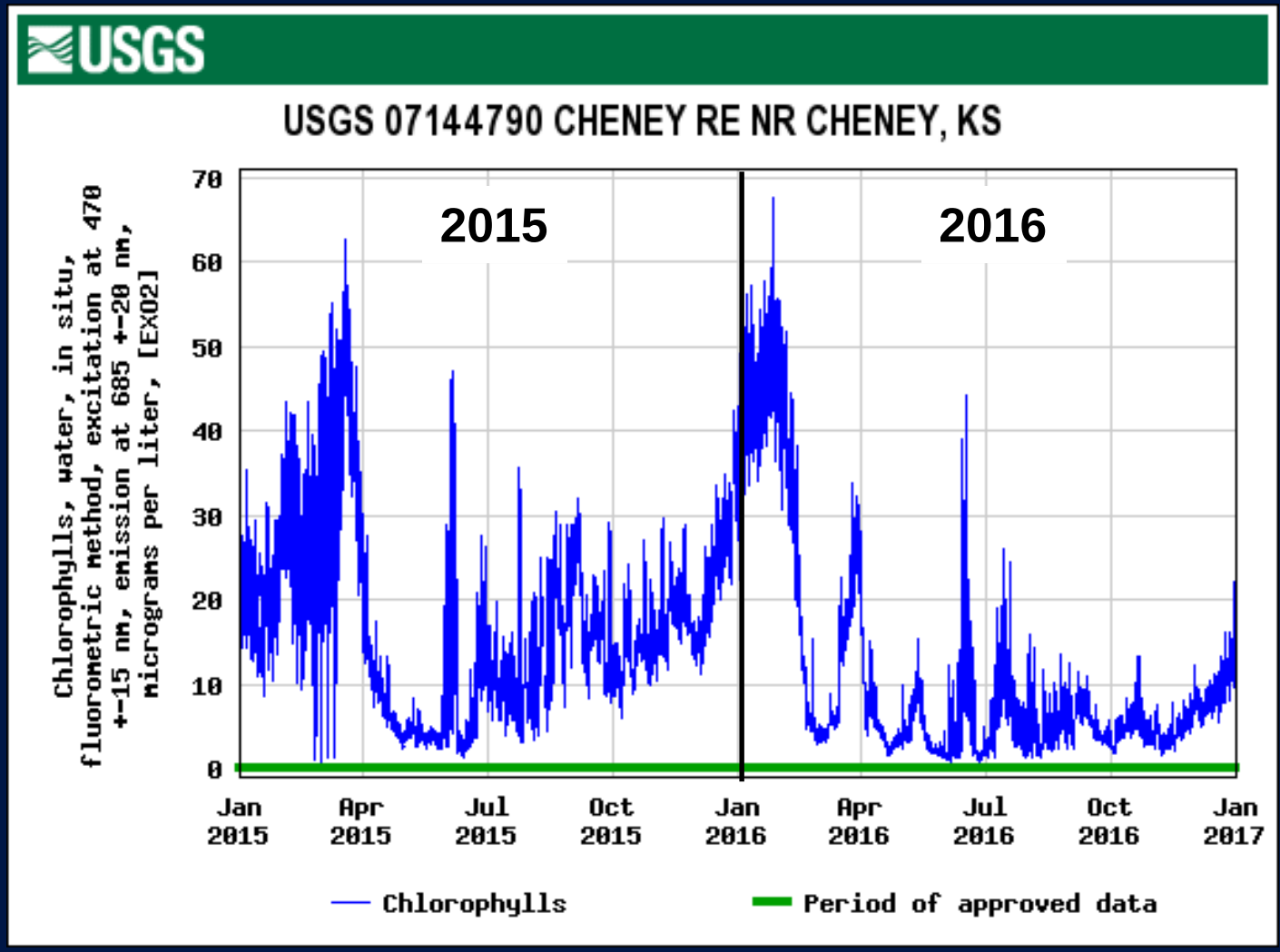
Algal Fluorescence May Be Indicative of Long-Term Patterns in Algal Activity



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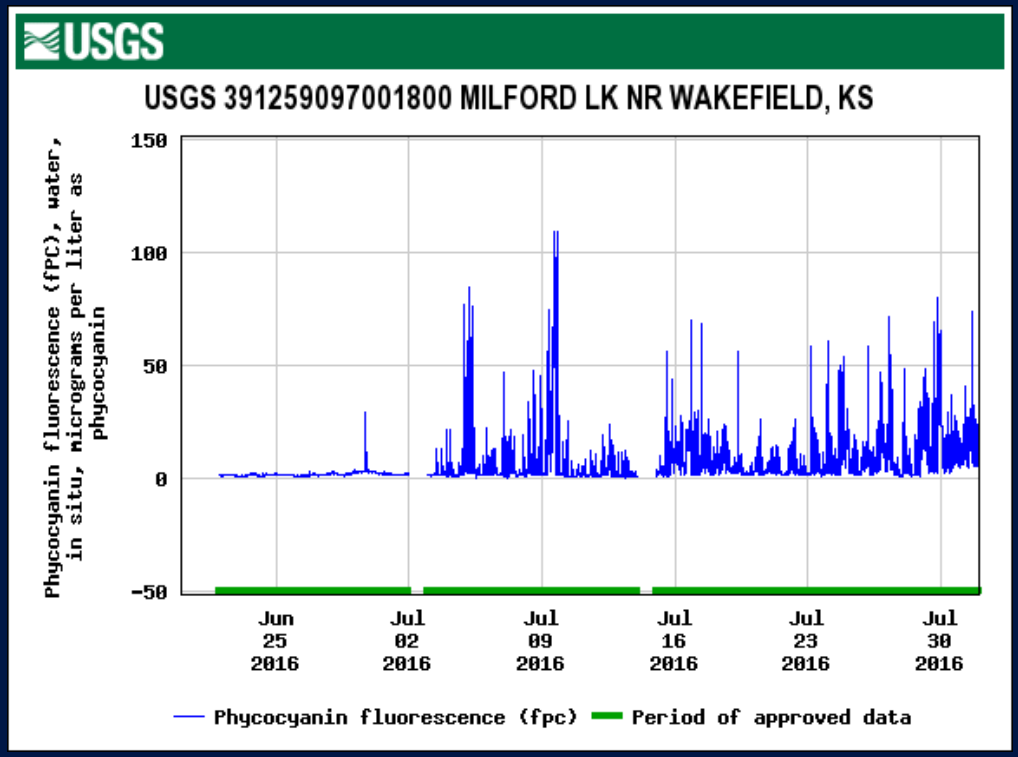
Noisy Patterns in Algal Fluorescence Also May Be Indicative of Potentially Harmful Algal Blooms

Courtesy of L. King



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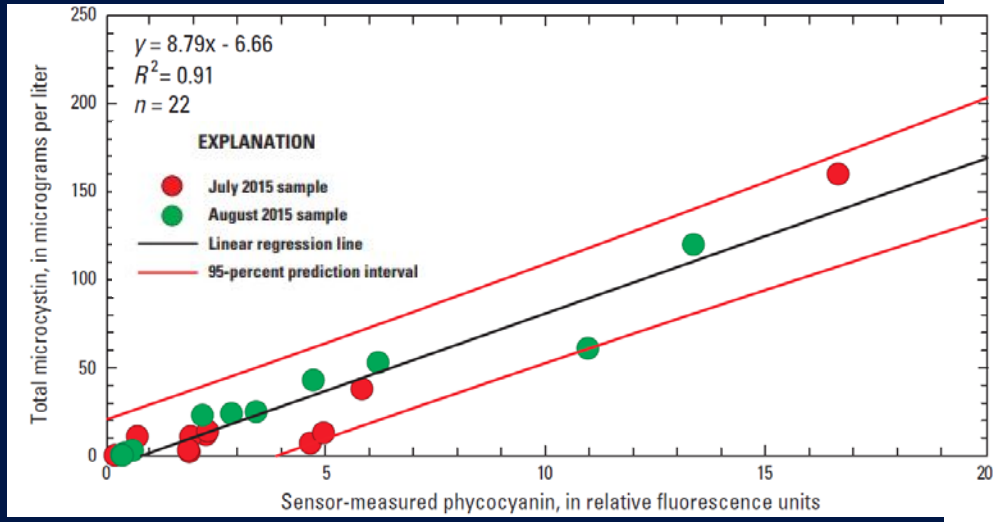
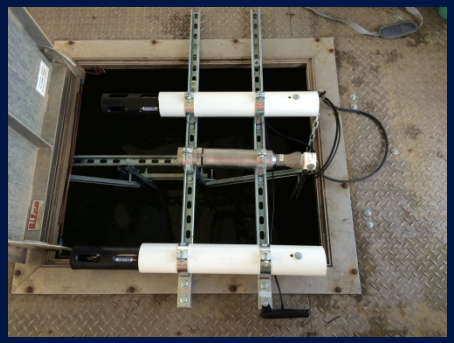
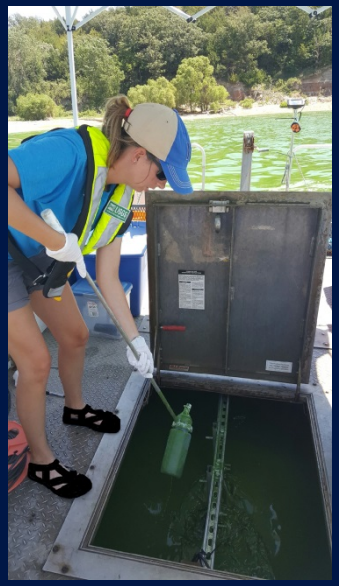
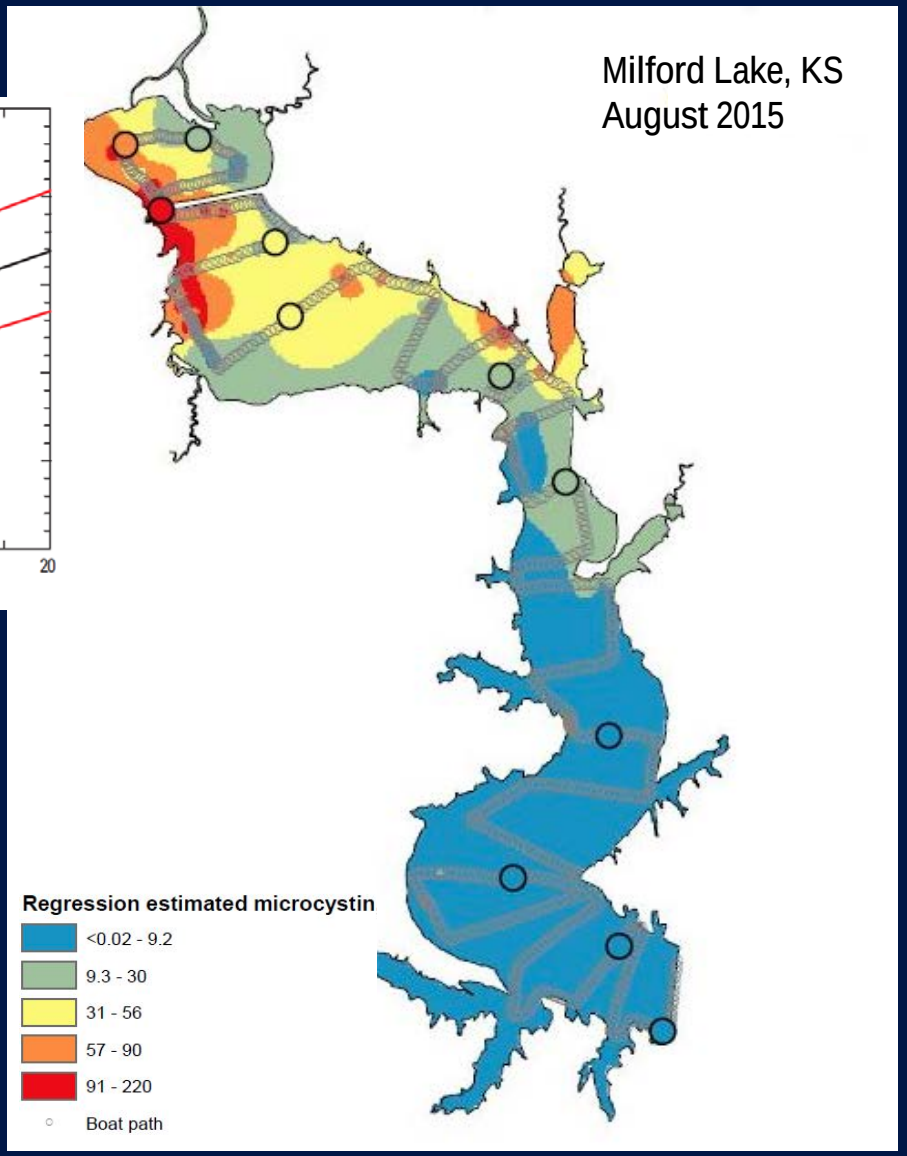
Surrogate Relations Can Be Developed to Map Spatial Variability in Cyanotoxin Concentrations









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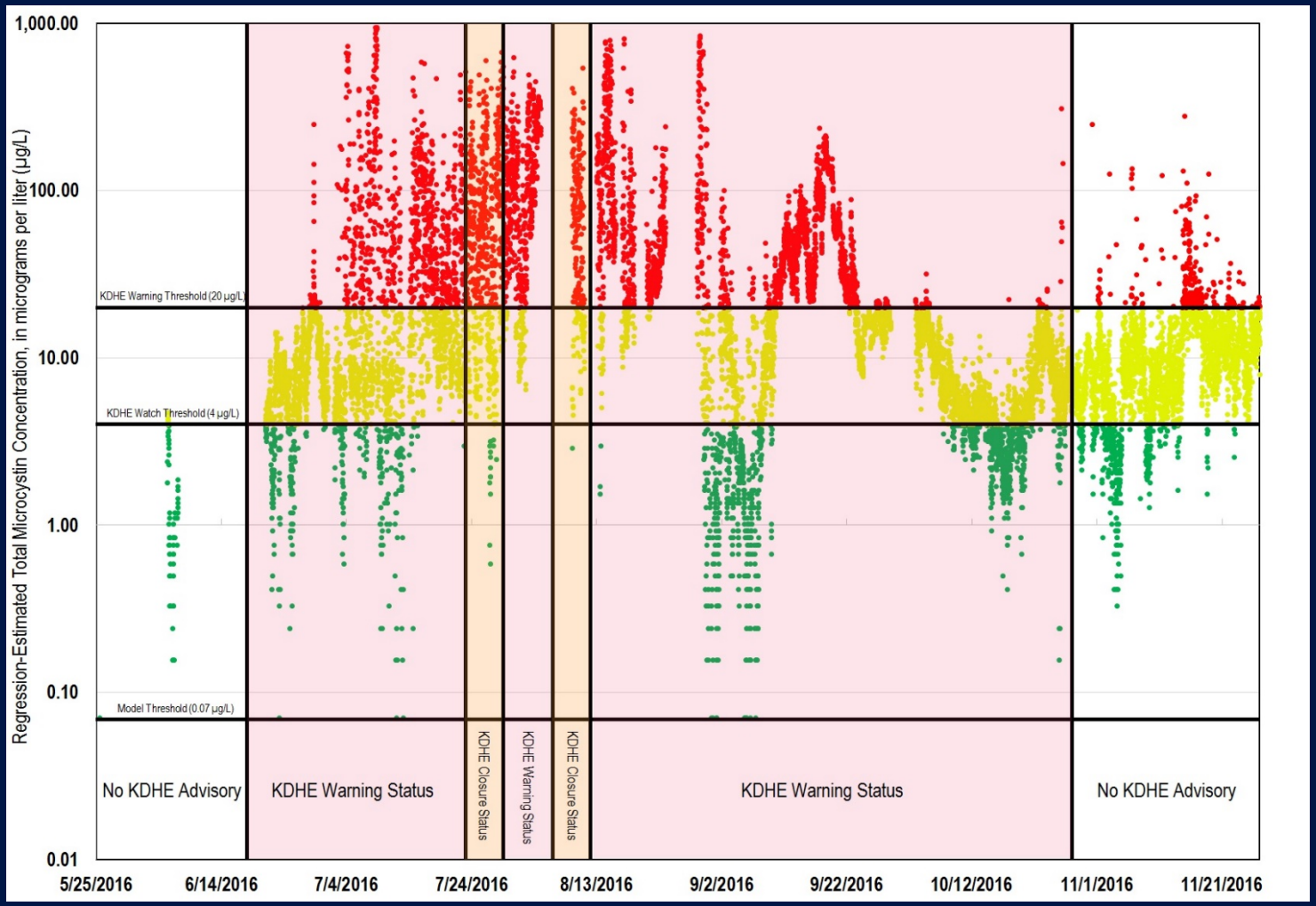
Foster and others, 2016
https://pubs.er.usgs.gov/publication/sir20165168

Continuous Water-Quality Monitors Can Be Used to Develop Models to Compute Cyanotoxin Concentrations in Real Time



Milford Lake at Wakefield, Data for Explanatory Variable (phycocyanin RFU)
Can Be Found At:
https://waterdata.usgs.gov/nwis/uv?site_no=391259097001800
Foster and others, in review

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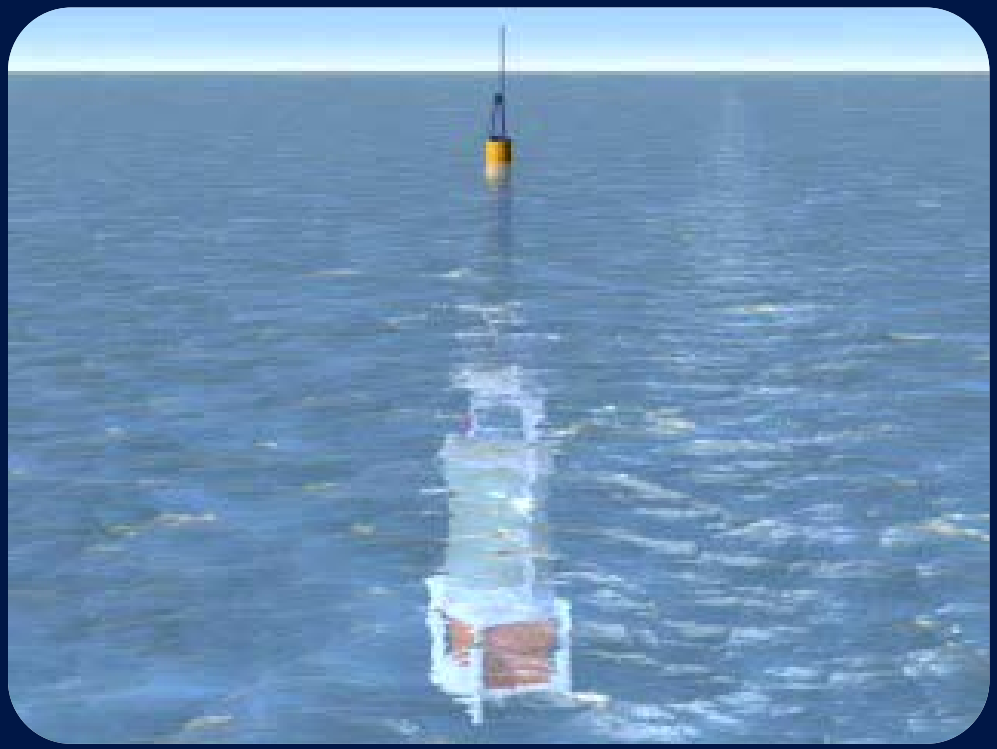
Autonomous Near Real-Time Toxin Detection for Lake Erie

- Purchased with GLRI funds post-Toledo Water crisis
- Collaboration between NOAA, MBARI, WHOI, OSU
- Truly emerging technology
  - Fewer than 20 worldwide
  - ESPniagara is the first in freshwater



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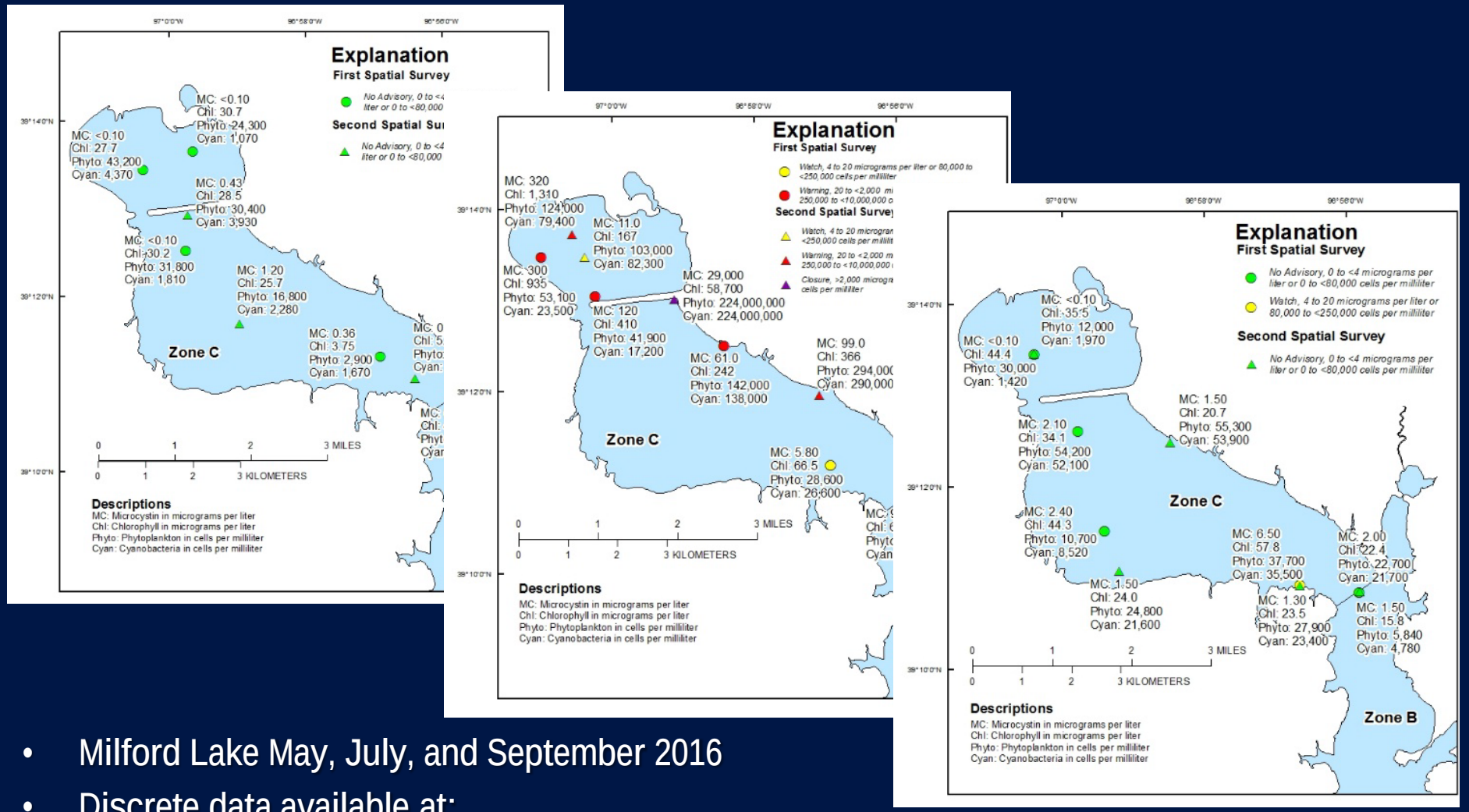
CILER Cooperative Institute for Limnology and Ecosystems Research

Courtesy of T. Davis

Discrete Samples Will Always Be Critical



- Milford Lake May, July, and September 2016
- Discrete data available at: http://dx.doi.org/10.5066/F7P55KJN

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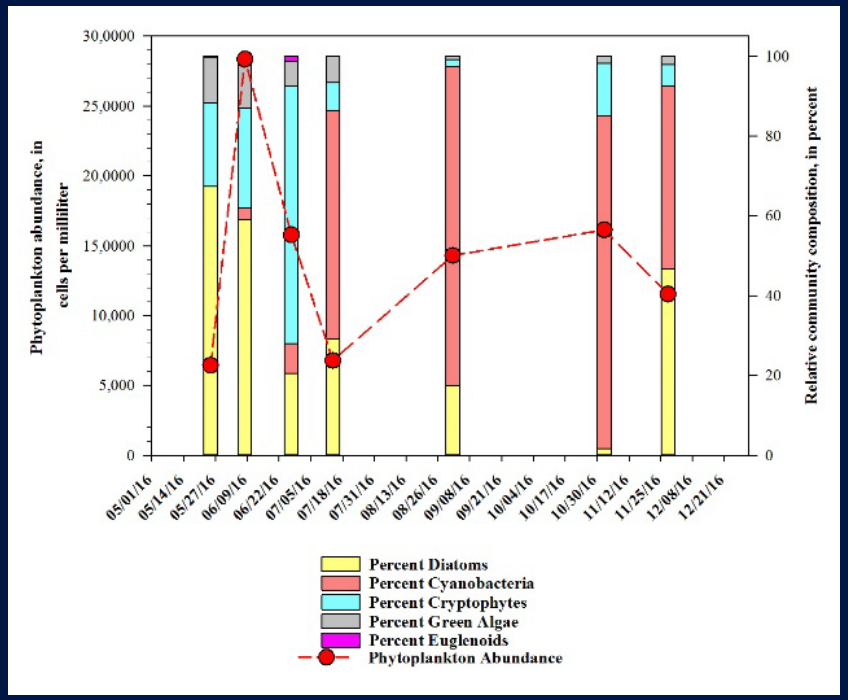
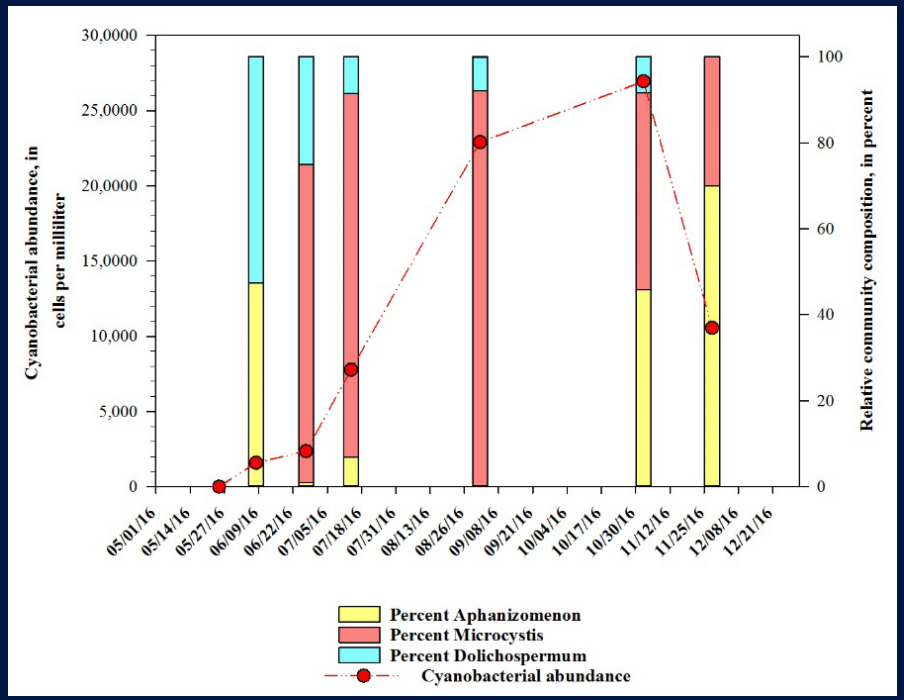
Phytoplankton & Cyanobacterial Abundance and Community Composition Give Critical System-Specific Insights That Can't Yet Be Measured (Reliably) by Sensors





Milford Lake May through December, 2016

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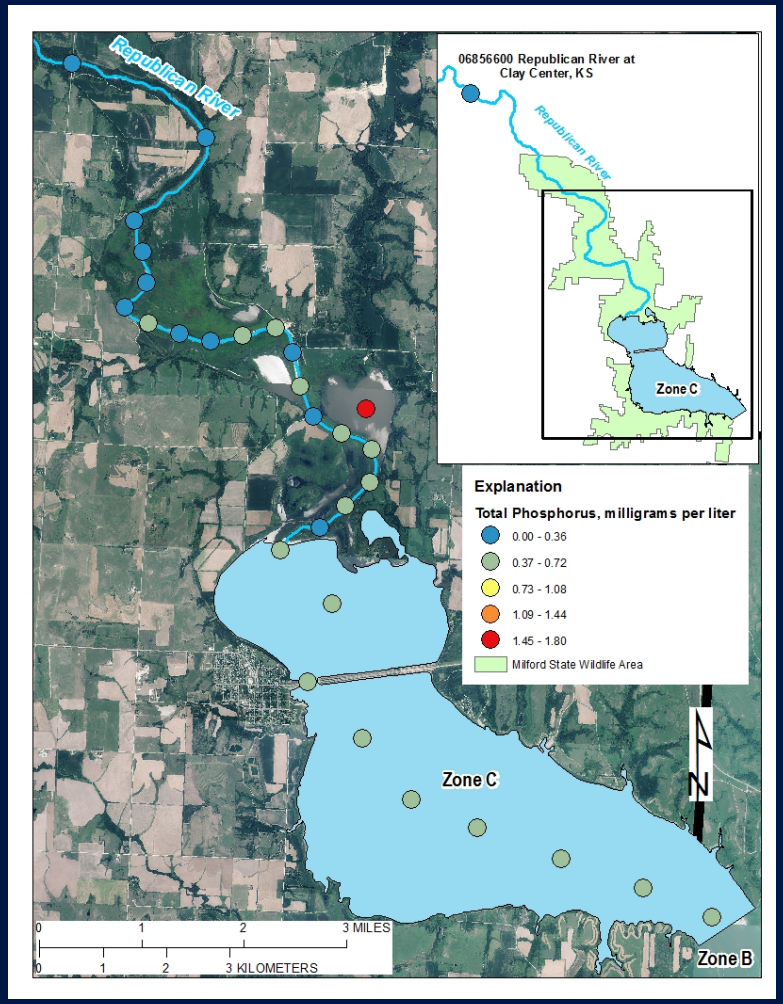
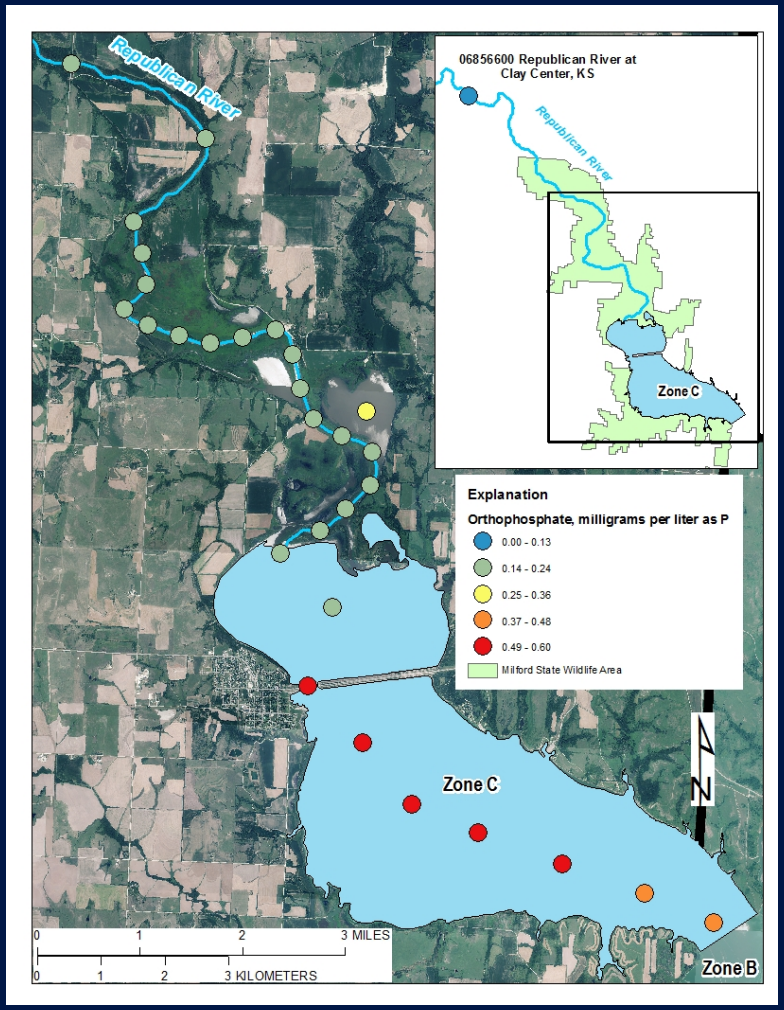
Nutrients Are Important Drivers of HABs





Milford Lake Total Phosphorus (left) and Orthophosphorus (right) on July 20, 2016

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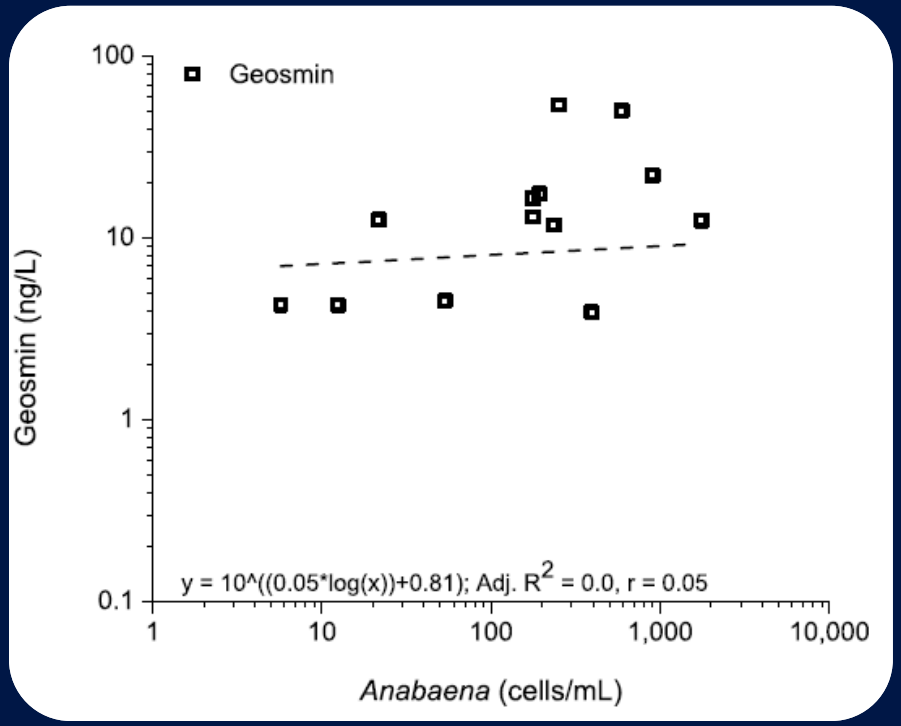
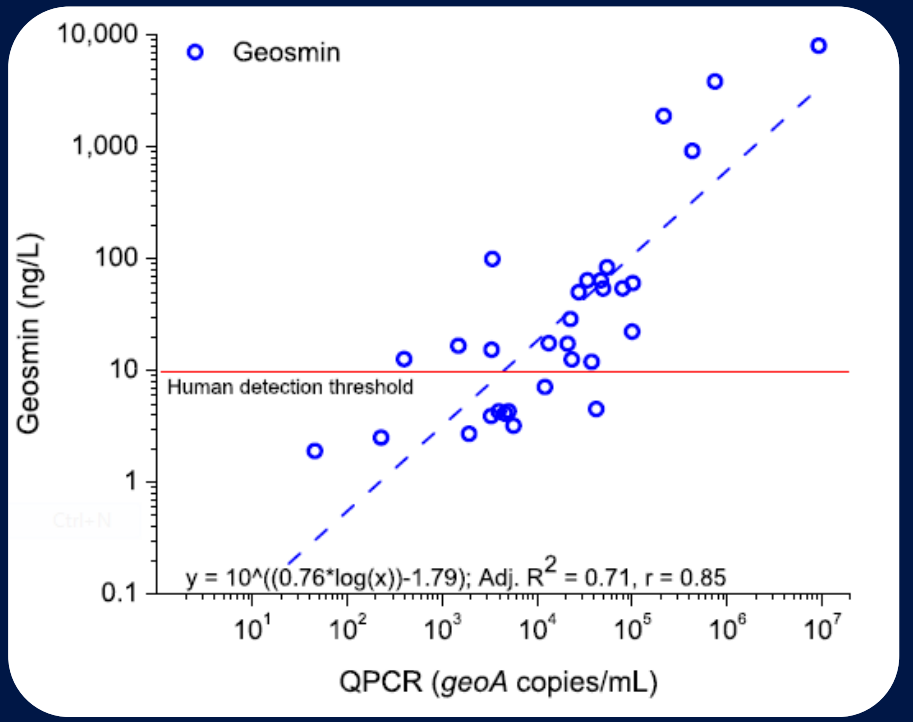
Genetic Data Improve Understanding of the Occurrence of Cyanobacteria and Associated Compounds

Can be utilized both independently or in conjunction with the other presented methods to achieve "integrated monitoring."





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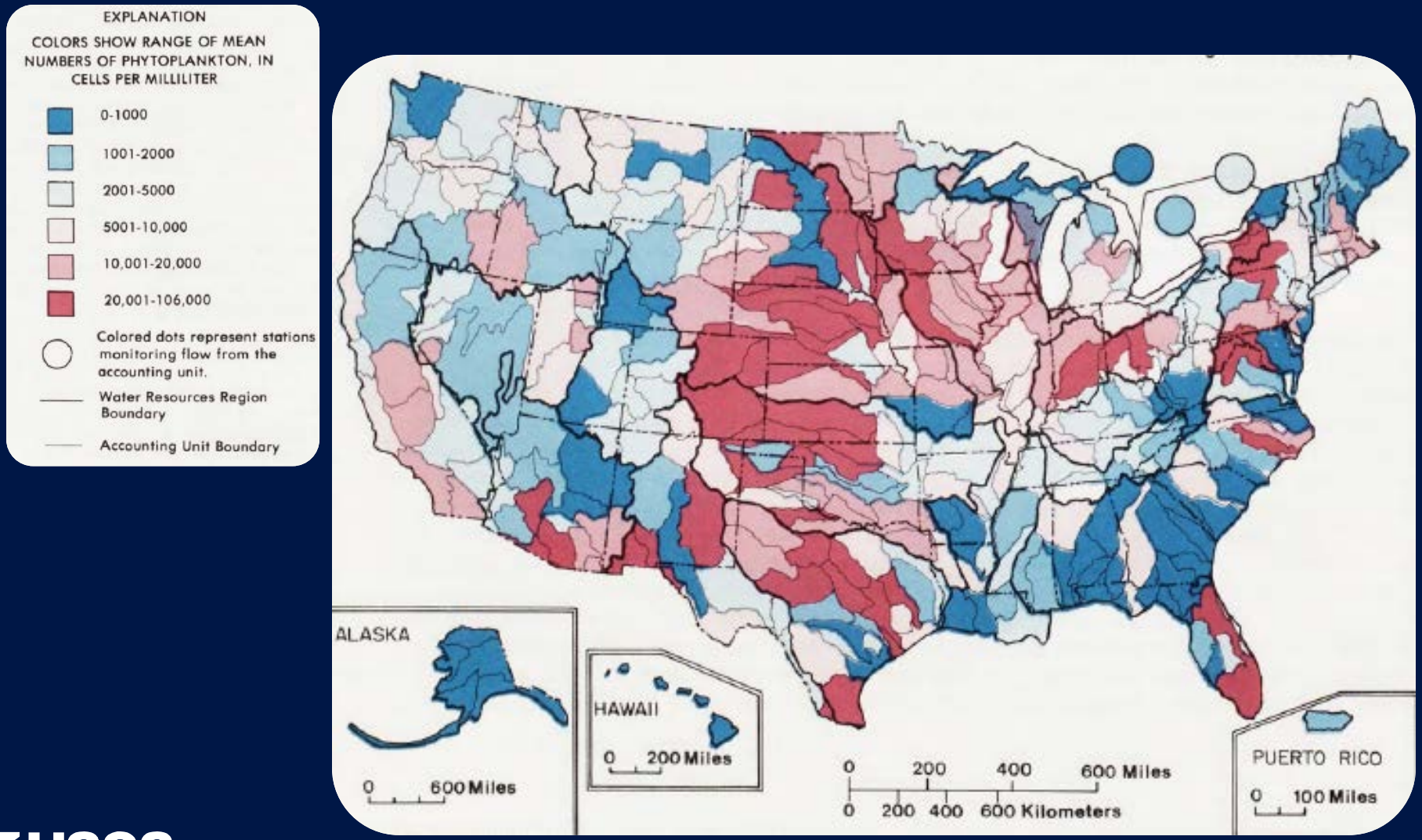
After Otten et al., 2016, Appl. Environ. Microbiol., 82: 5410-5420
http://aem.asm.org/content/82/17/5410.full.pdf

Legacy Data Are Essential to Understanding Status and Trends



USGS WY1975 NASQAN Data, *n*=345
After Briggs and Ficke, 1977

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Phytoplankton Abundance in Kansas Rivers During 1973-1981

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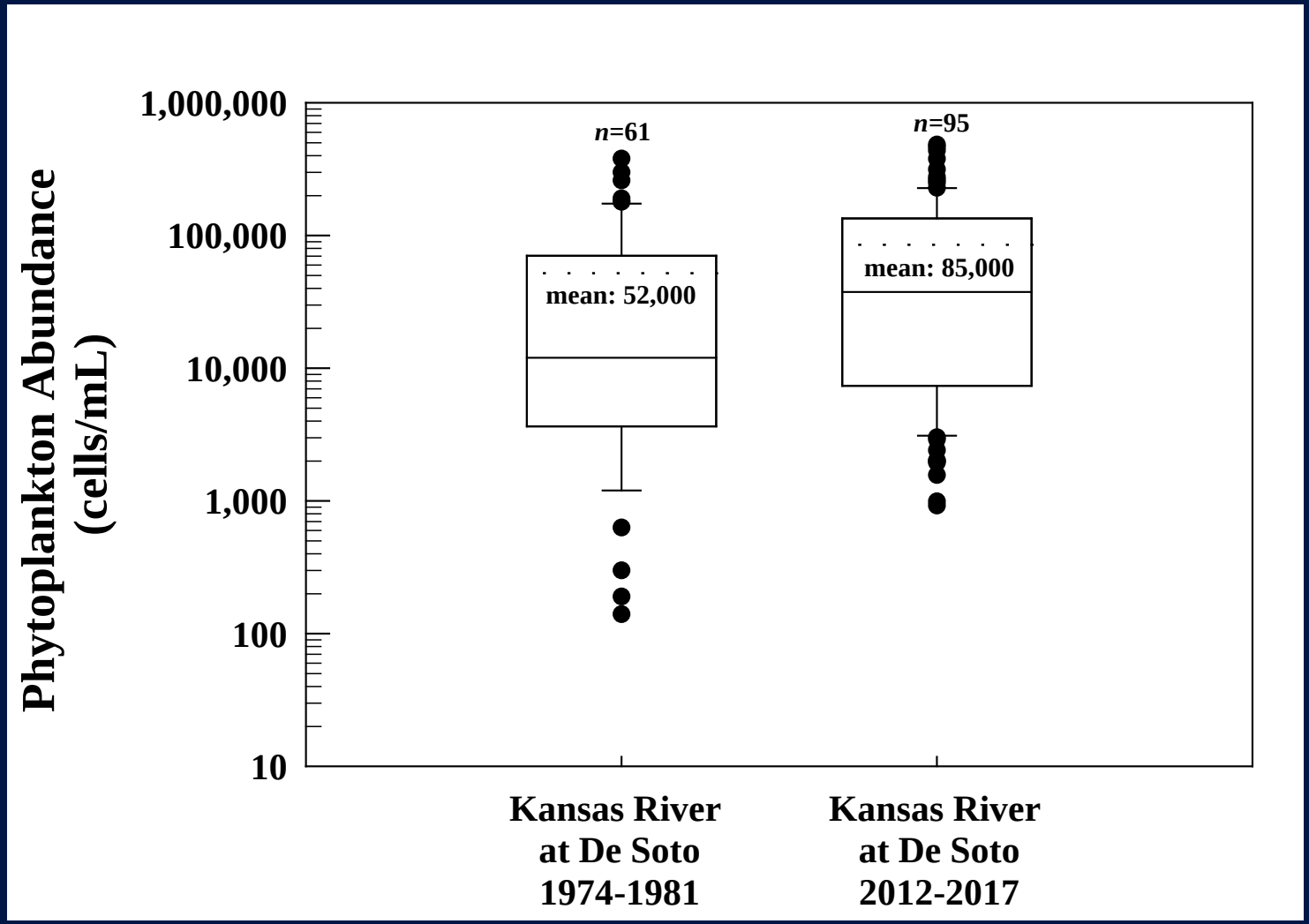
USGS NASQAN Data: 1973-1981

Phytoplankton Abundance in the Kansas River: Yesterday and Today



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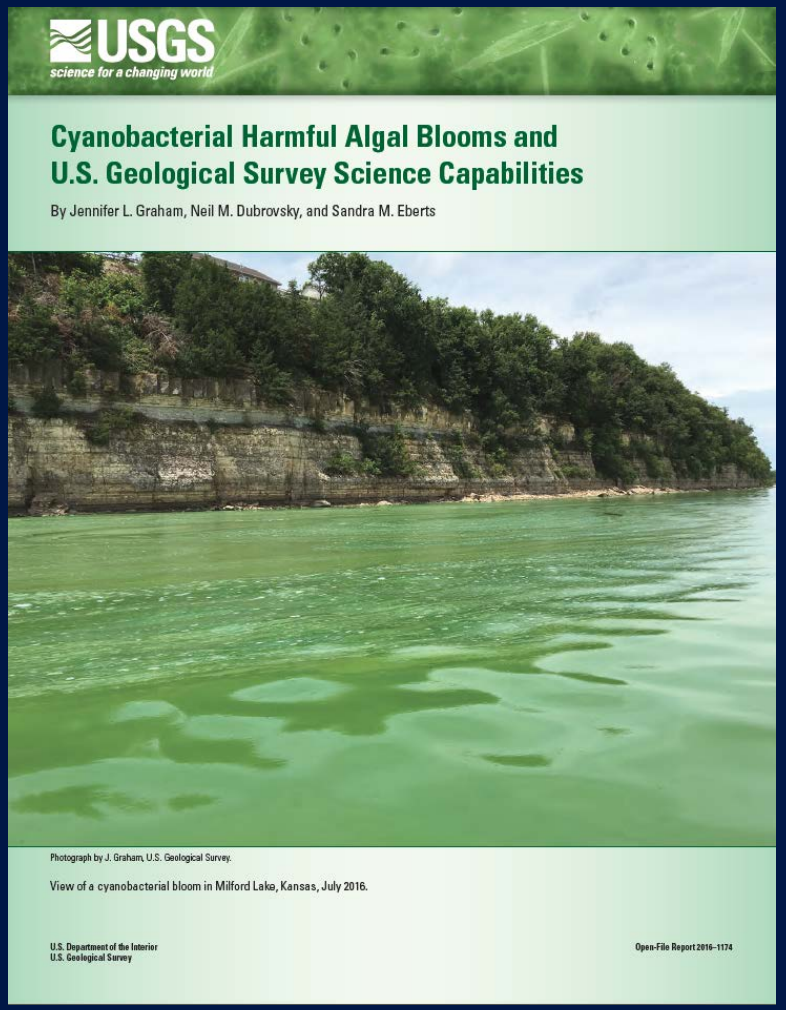
Integrated Approaches are Essential to Understand, Quantify, and Mitigate Harmful Algal Blooms

- Status and trends
- Environmental fate and transport
- Environmental drivers
- Ecosystem effects
- Exposure and health
- Drinking water and food impacts
- Mitigation and management



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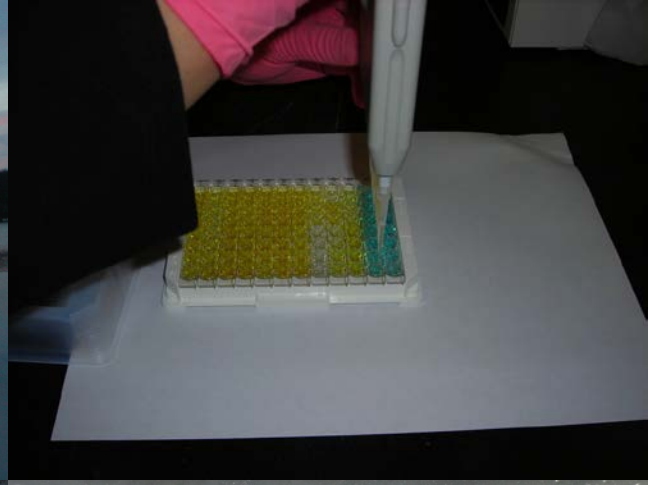


USGS:

https://www.usgs.gov/news/science-harmful-algae-blooms

http://ks.water.usgs.gov/cyanobacteria

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